

Modeling the influence of the Dardanelles outflow on the Aegean Sea dynamics

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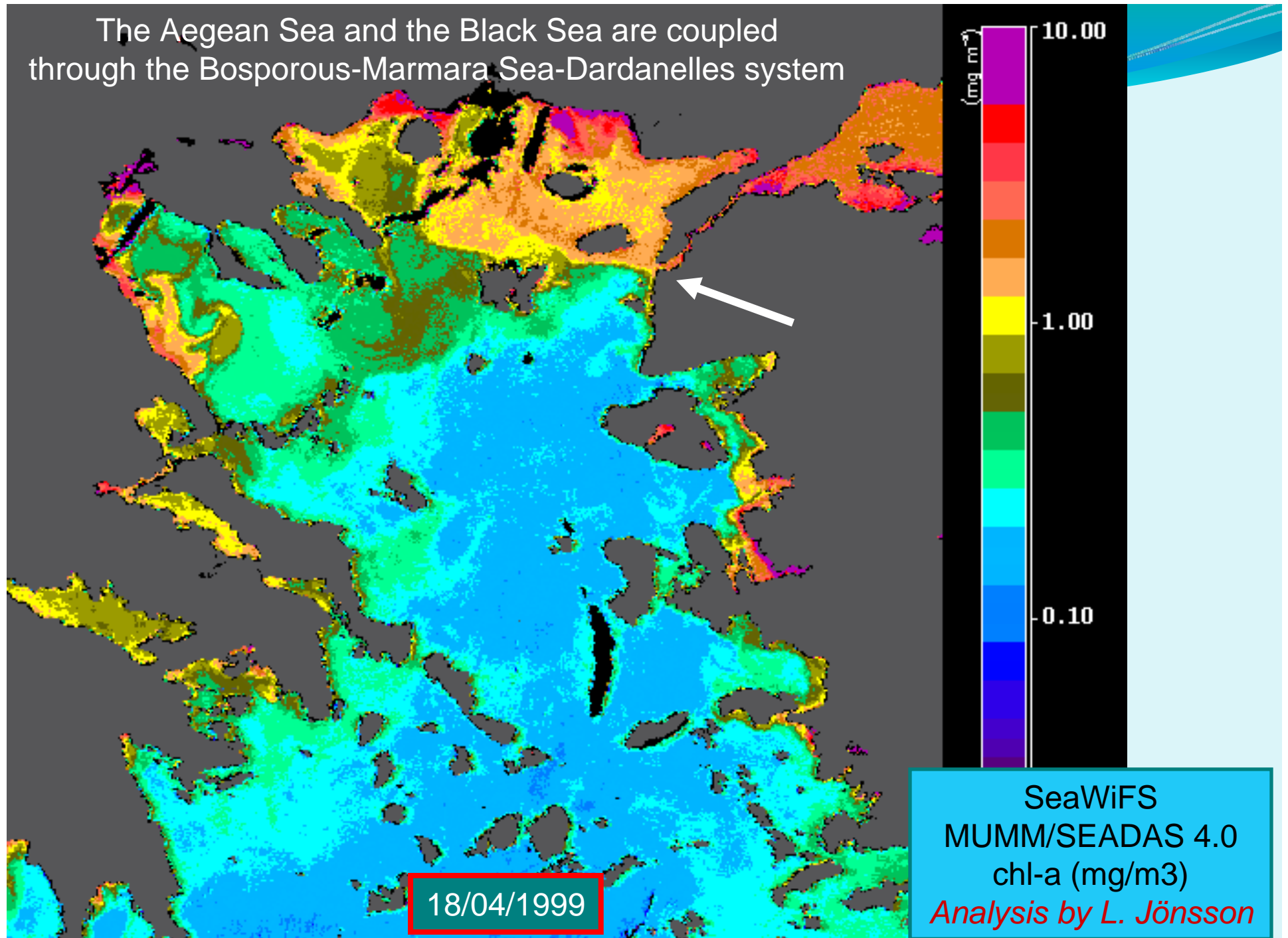
S. Besiktepe (NURC, Italy/international)

EU-SESAME project (HCMR, coordinator)



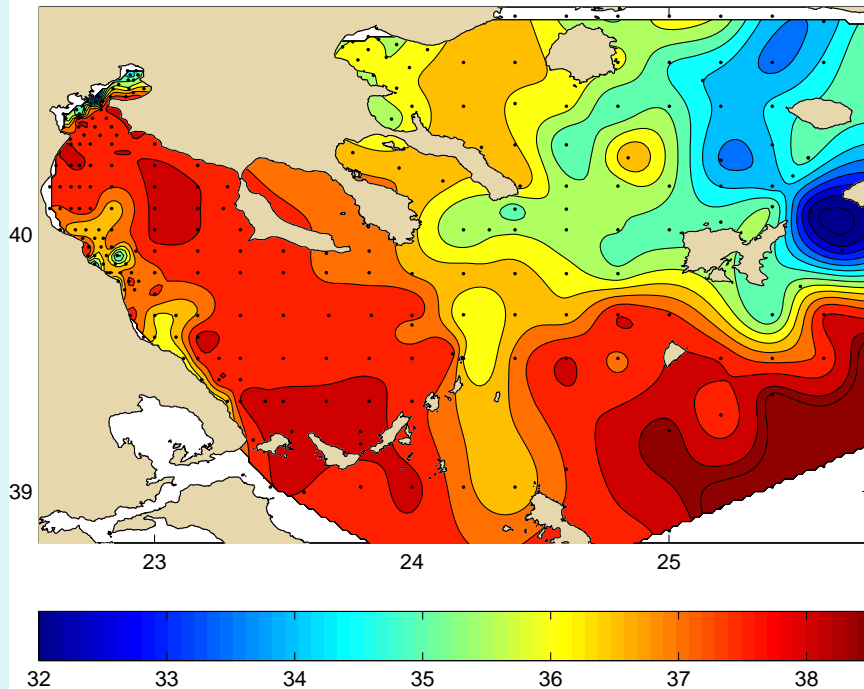
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The Aegean Sea and the Black Sea are coupled through the Bosphorous-Marmara Sea-Dardanelles system



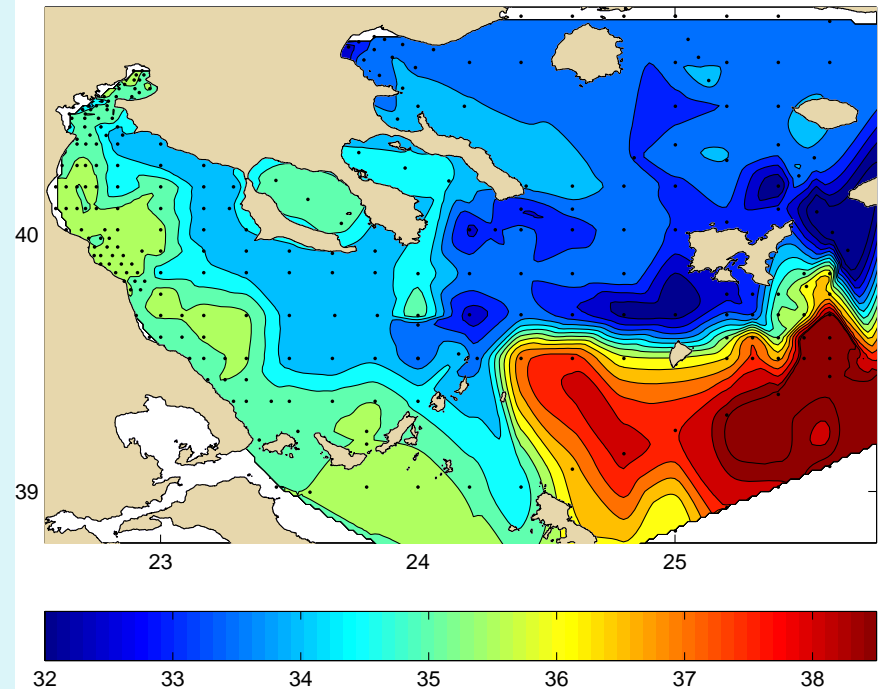
Observations: 1997-1998 hydrography

Salinity at 5m (psu) / May 1997



Salinity
(May 1997)

Salinity at 5m (psu) / September 1998



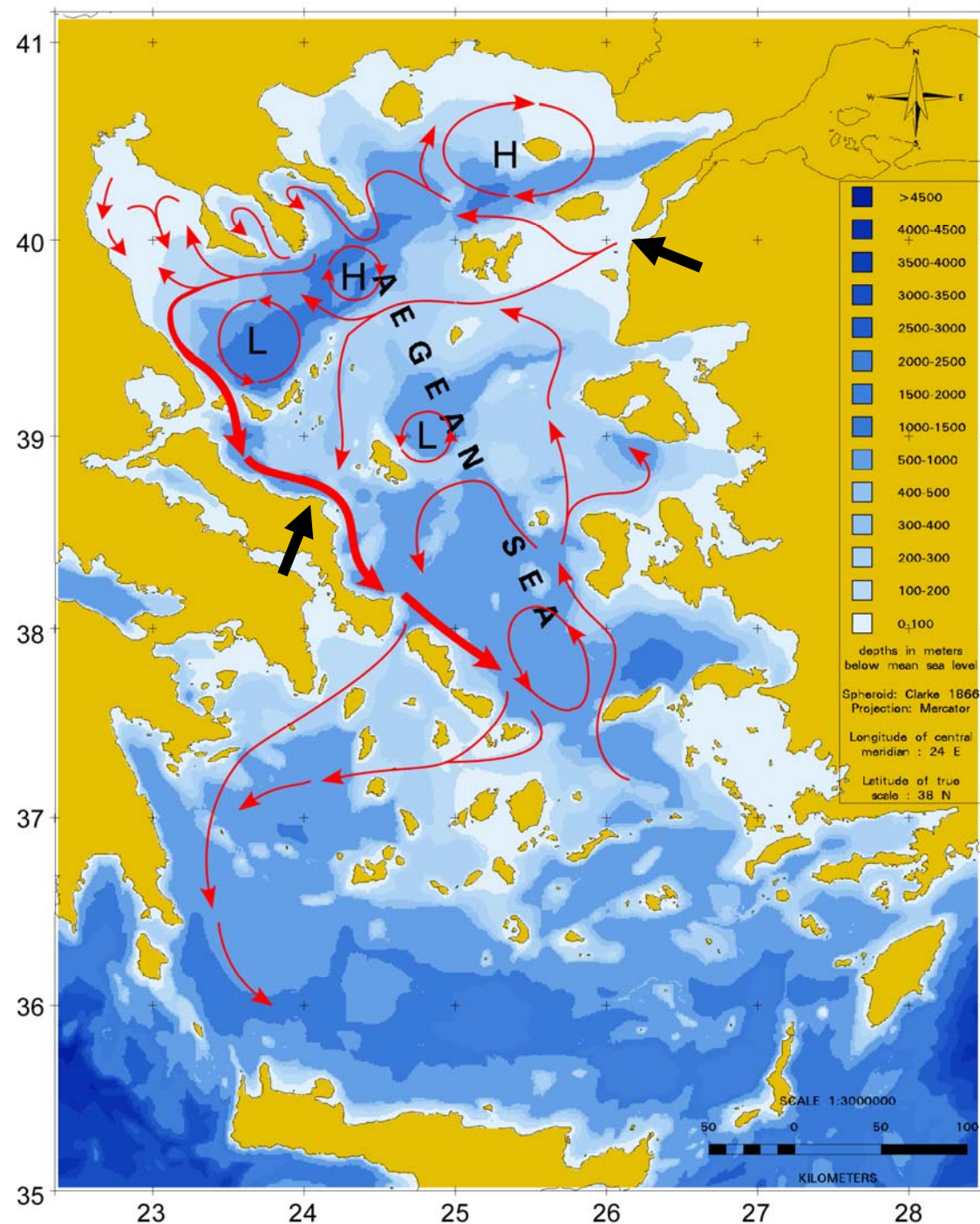
Salinity
(Sept. 1998)

Data provided by:
H. Kontoyiannis (METROMED) and
G. Georgopoulos, V. Zervakis (INTERREG)

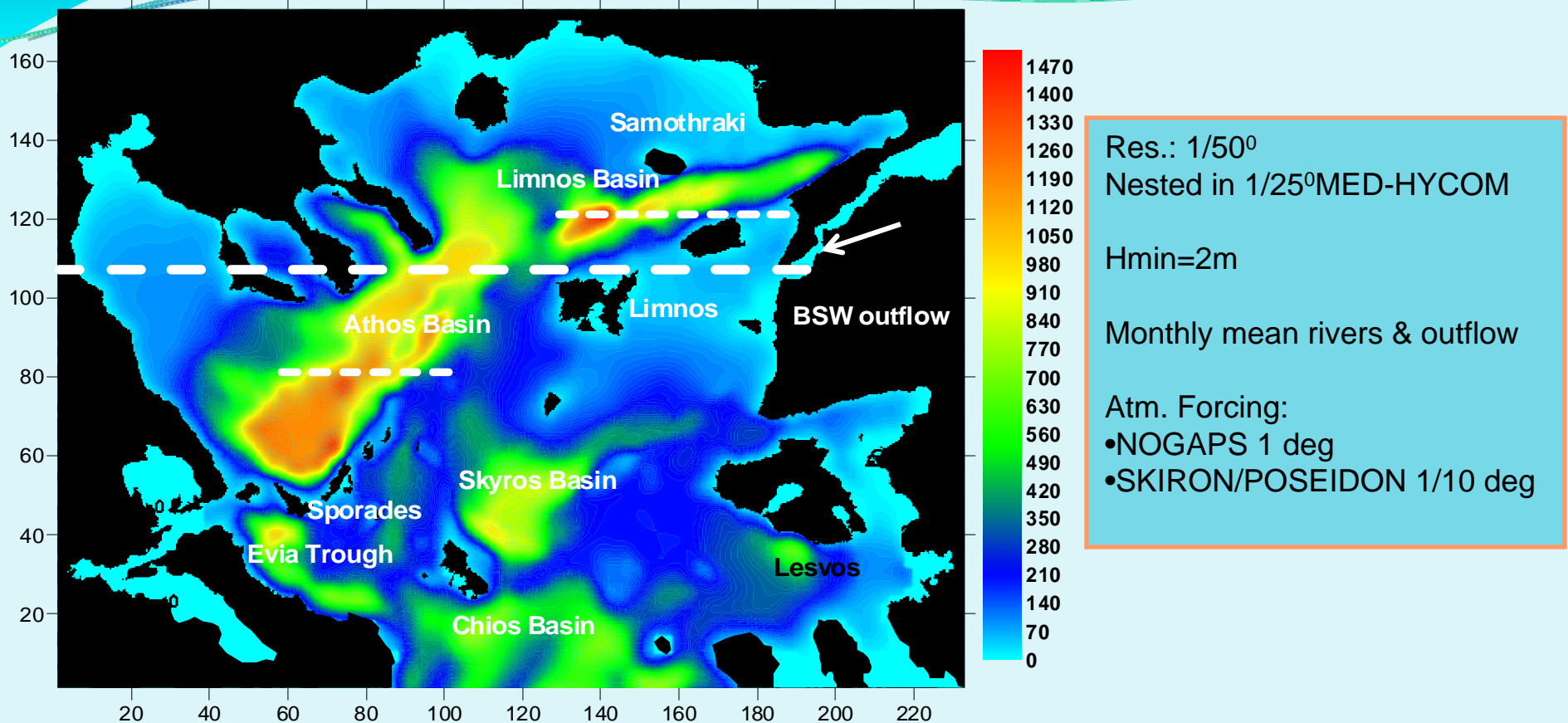
Observations: The 2002-2003 Drifter study

- 4 deployments
(March, June, Sept. 2002;
Febr. 2003)
- 45 drifters
- ~ 10 m drogue
depth
- Generally deployed
at depths larger than
200 m

Olson et al., JPO 2007

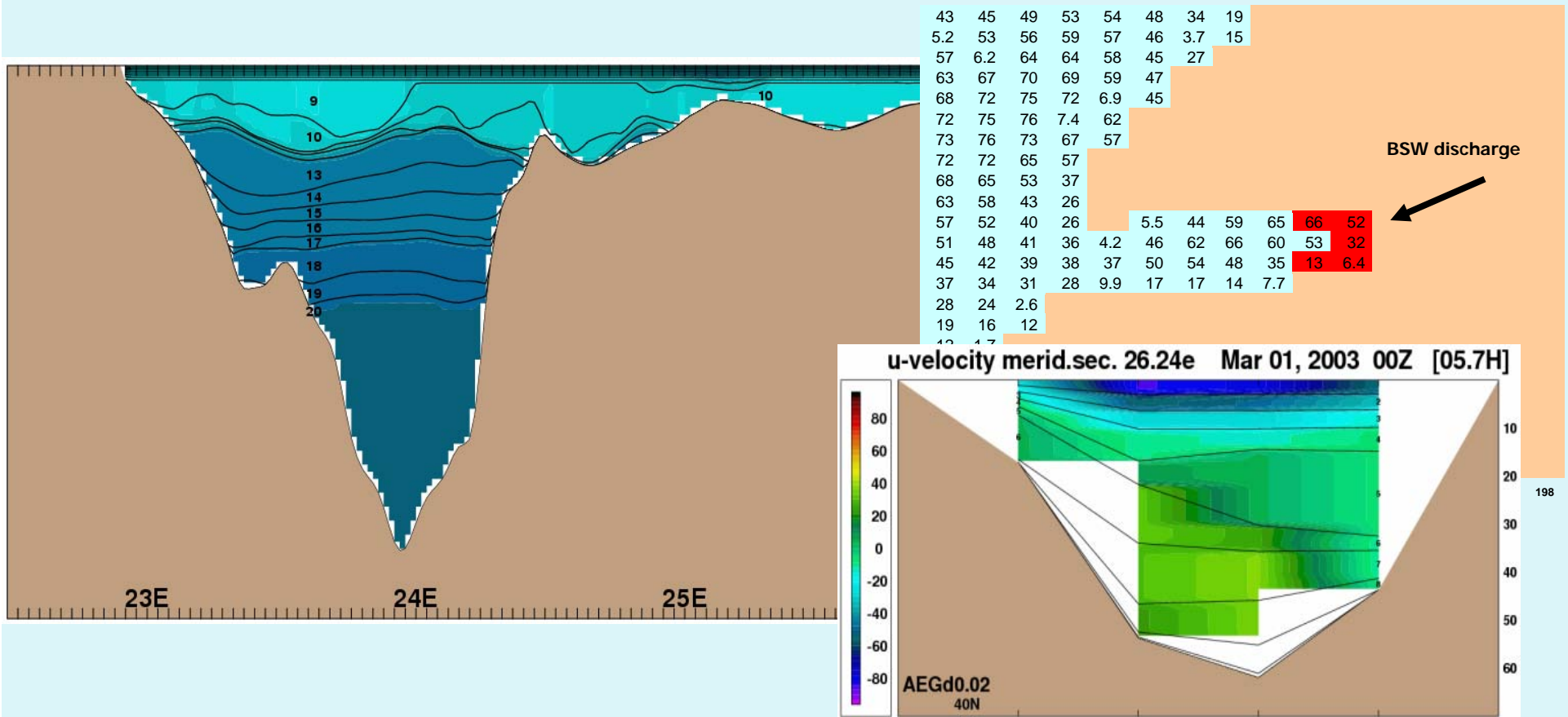


The North Aegean Hybrid Coordinate Ocean Model (NAEG-HYCOM)



- What is the role of outflow properties, strait dynamics and atmospheric forcing in the development of the Dardanelles plume?
- How does the transport and fate of BSW waters vary in seasonal and inter-annual time scales, how is it modified by the complex topography and how does it impact the North Aegean general circulation?
- What is the role of BSW on the North Aegean dense water formation?

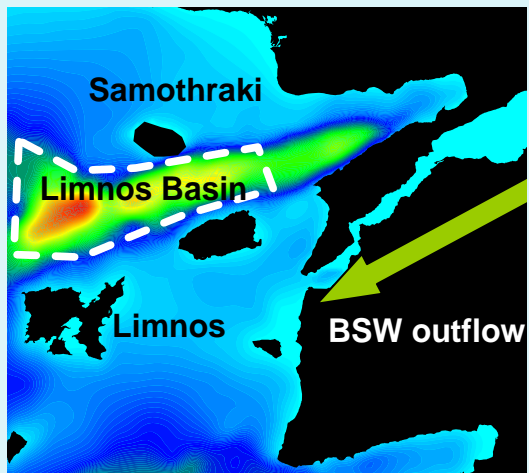
Model simulations– Study Period 2002-2009



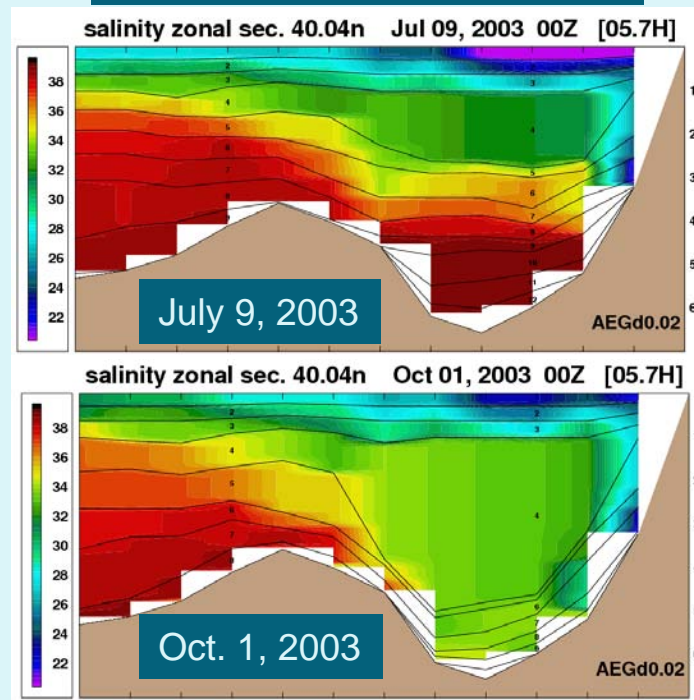
Dardanelles outflow current parameterization: modified river upper layer inflow over top 25 m and spread over 5 cells
(Schiller and Kourafalou, 2009; Besiktepe, 1994)

Dardanelles Outflow: variability in buoyancy input

- Maximum: Spring - Summer
- Minimum: Autumn - Winter



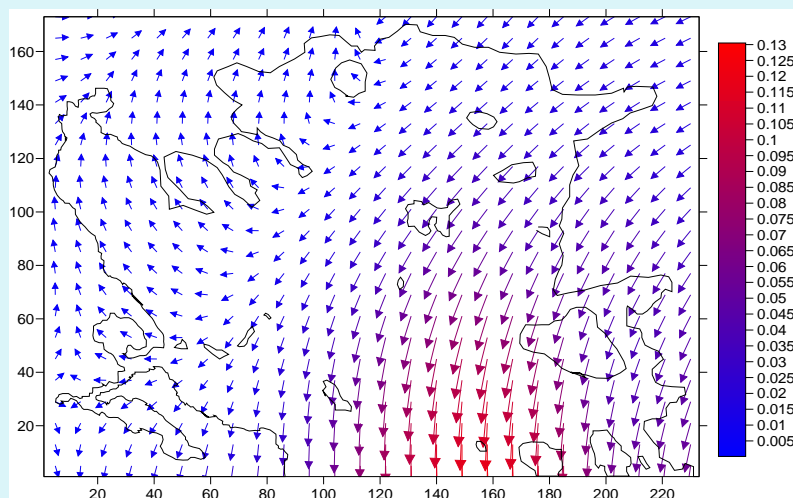
2 layer outflow structure



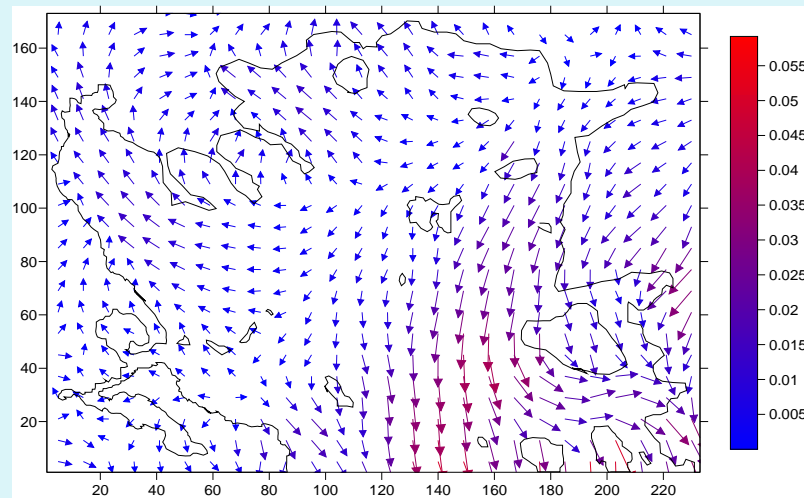
- BSW outflow is the largest lateral buoyancy input in the Eastern Med.
- The BSW pathways exhibit variability in many time scales and are largely influenced by the complex topography
- Parameterizations of outflow properties influence basin scale dynamics
- Employ new data from ancillary projects (ONR-Poulain, NRL-Jarosz, NURC-Besiktepe, EU-SESAME)

BSW pathways: influence of atmospheric forcing and topographic constraints

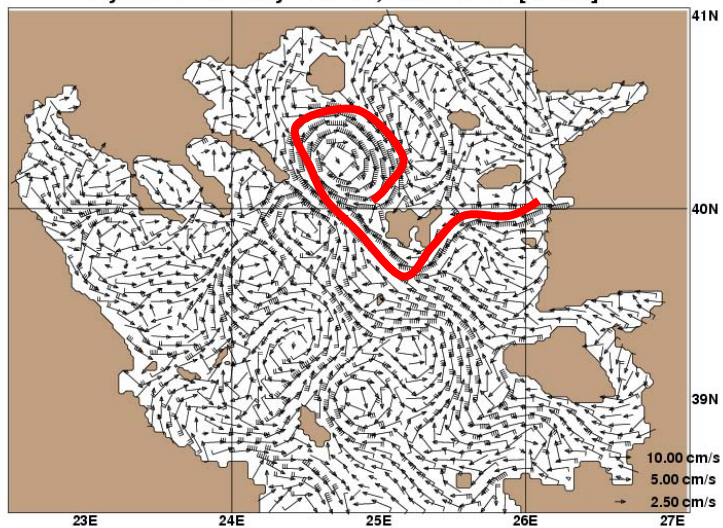
NOGAPS (resolution: 1 degree)



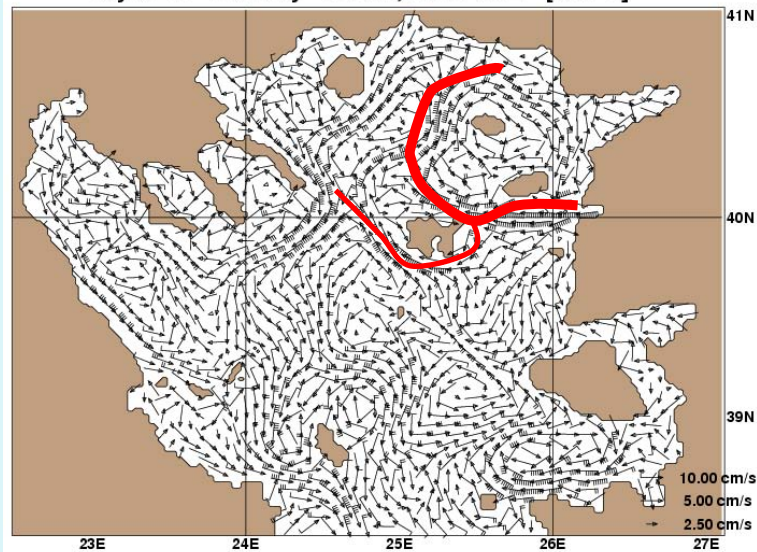
SKIRON (resolution: 1/10 degree)



layer=01 velocity Jul 02, 2003 00Z [02.9H]



layer=01 velocity Jul 02, 2003 00Z [03.7H]



➤ Details in high res. wind curl allow the bifurcation of the BSW pathways

SST evaluation (3/26/03)

MODEL
(w/ NOGAPS)

MODIS SST

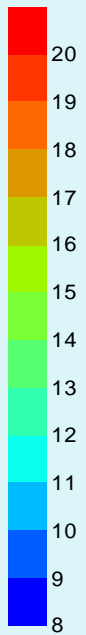
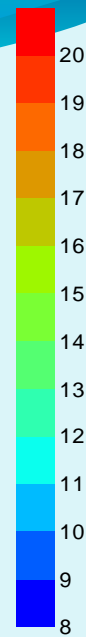
26 March MODIS-SST

26 March NAEG-HYCOM SST
(NOGAPS)

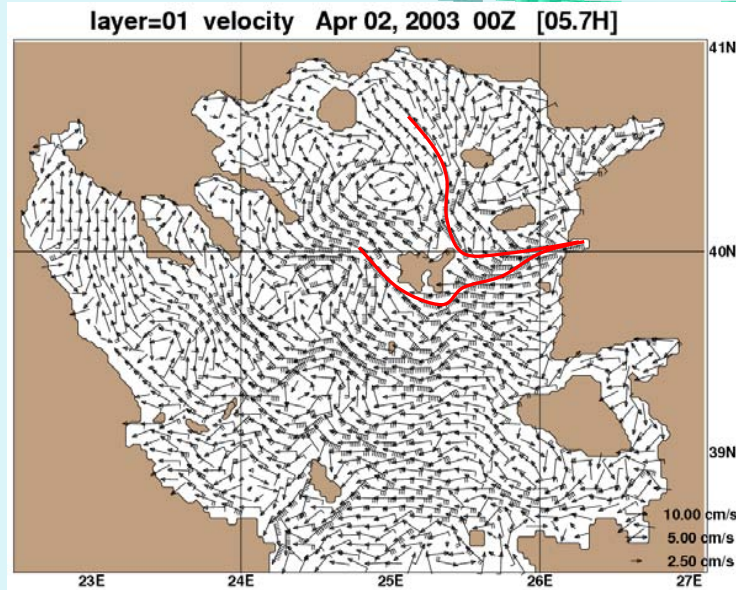
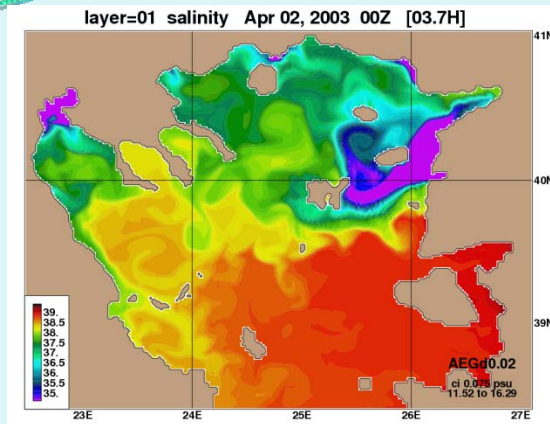
26 March NAEG-HYCOM SST
(SKIRON)

- Atmospheric fluxes
- BSW temperature

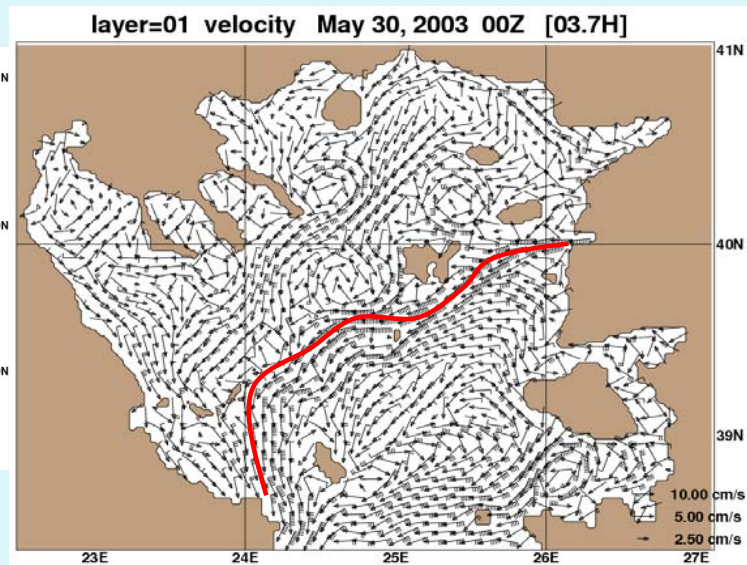
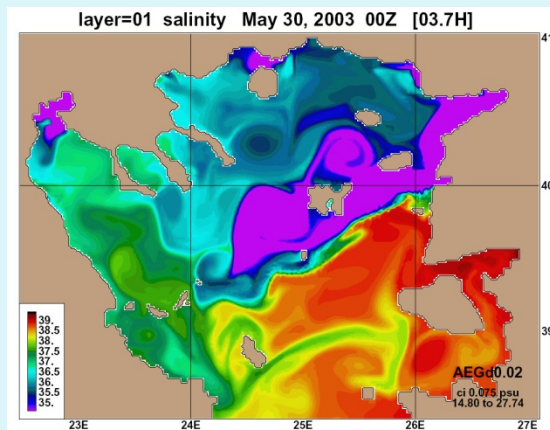
MODEL
(w/ SKIRON)



BSW pathways: influence on local and basin-wide dynamics

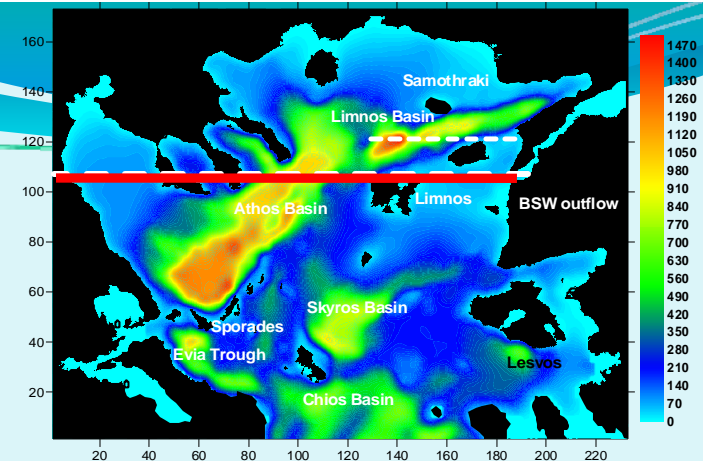
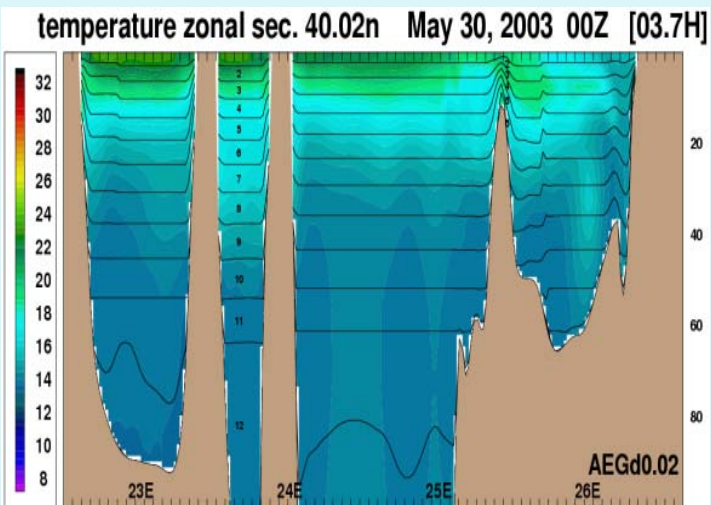
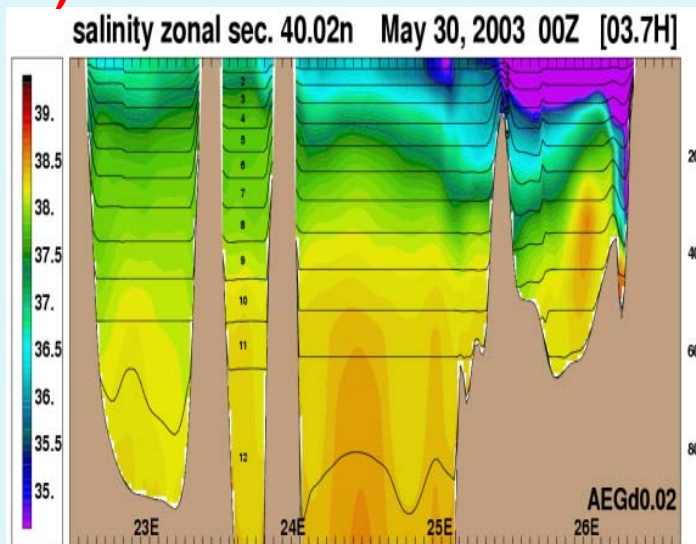


2 April 2003
No cross basin influence



30 May 2003
Strong cross basin influence

BSW pathways: cross-basin structure (upper 100m)

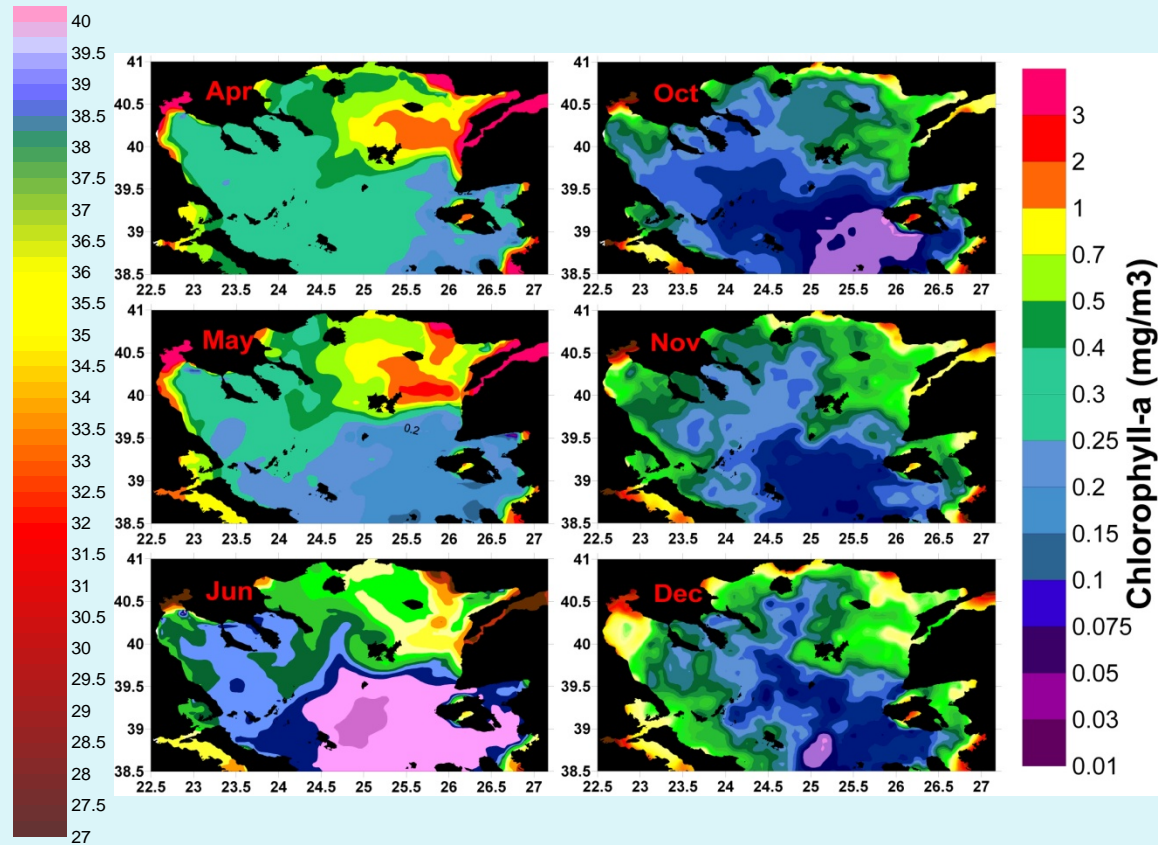
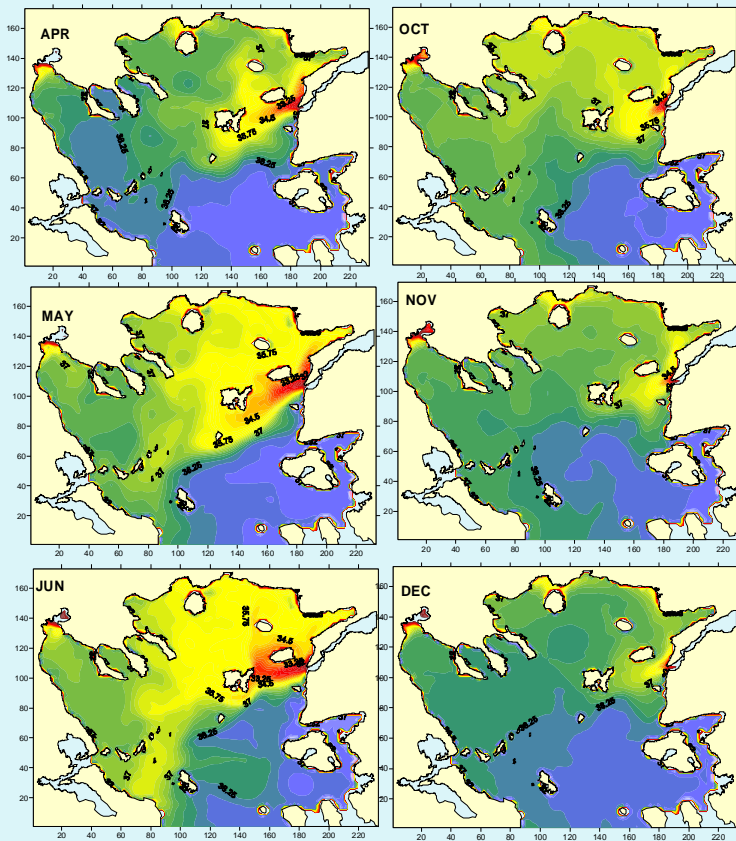


30 May 2003
Strong cross basin
influence

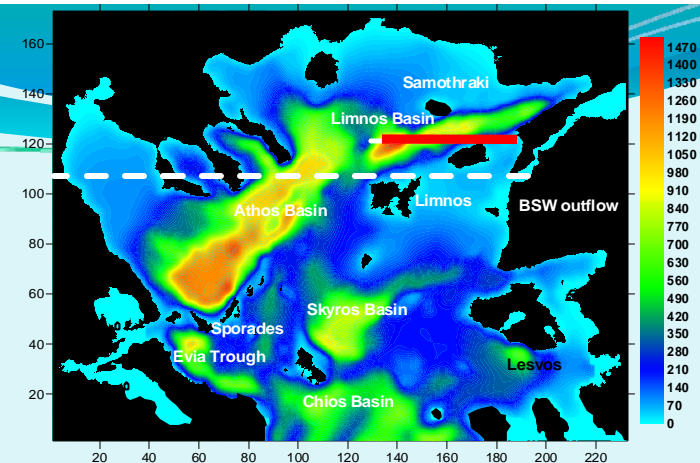
BSW pathways: seasonal variability (spring/left panels– fall/right panels)

SALINITY (model)

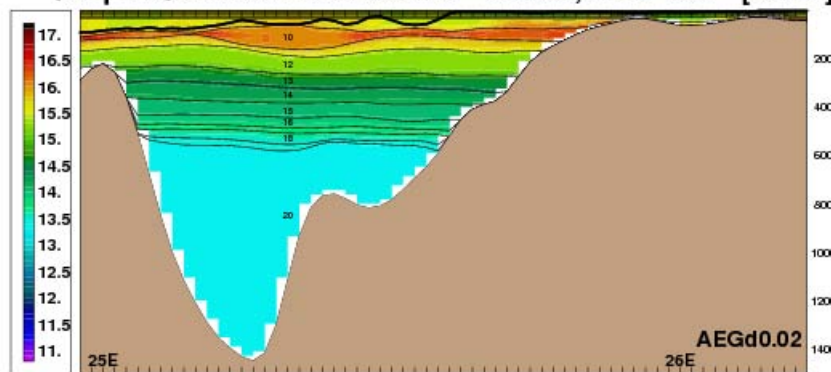
Chl-a (SeaWiFS data)



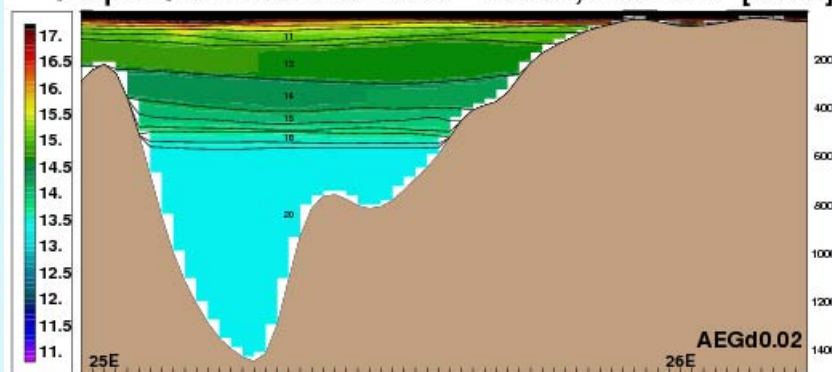
Vertical structure in the Limnos deep basin (1400 m)



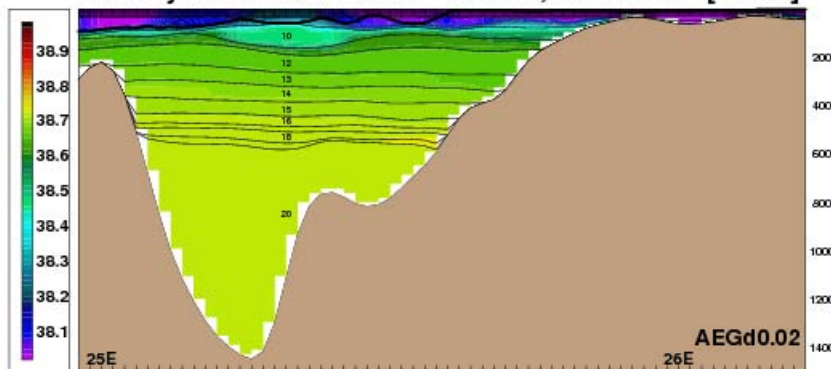
temperature zonal sec. 40.24n Feb 09, 2003 00Z [05.7H]



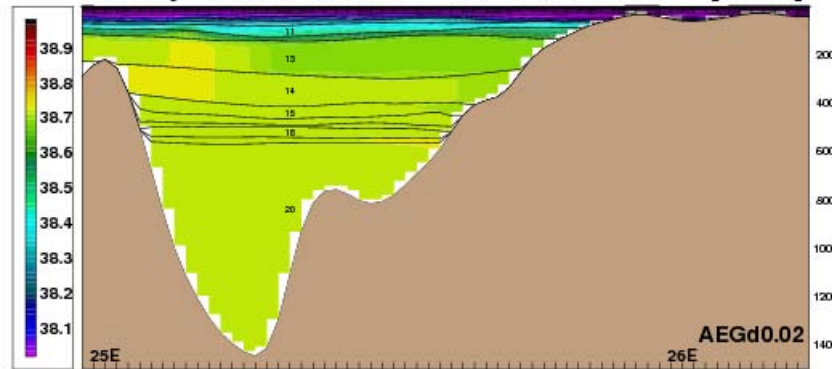
temperature zonal sec. 40.24n Jun 29, 2003 00Z [05.7H]



salinity zonal sec. 40.24n Feb 09, 2003 00Z [05.7H]



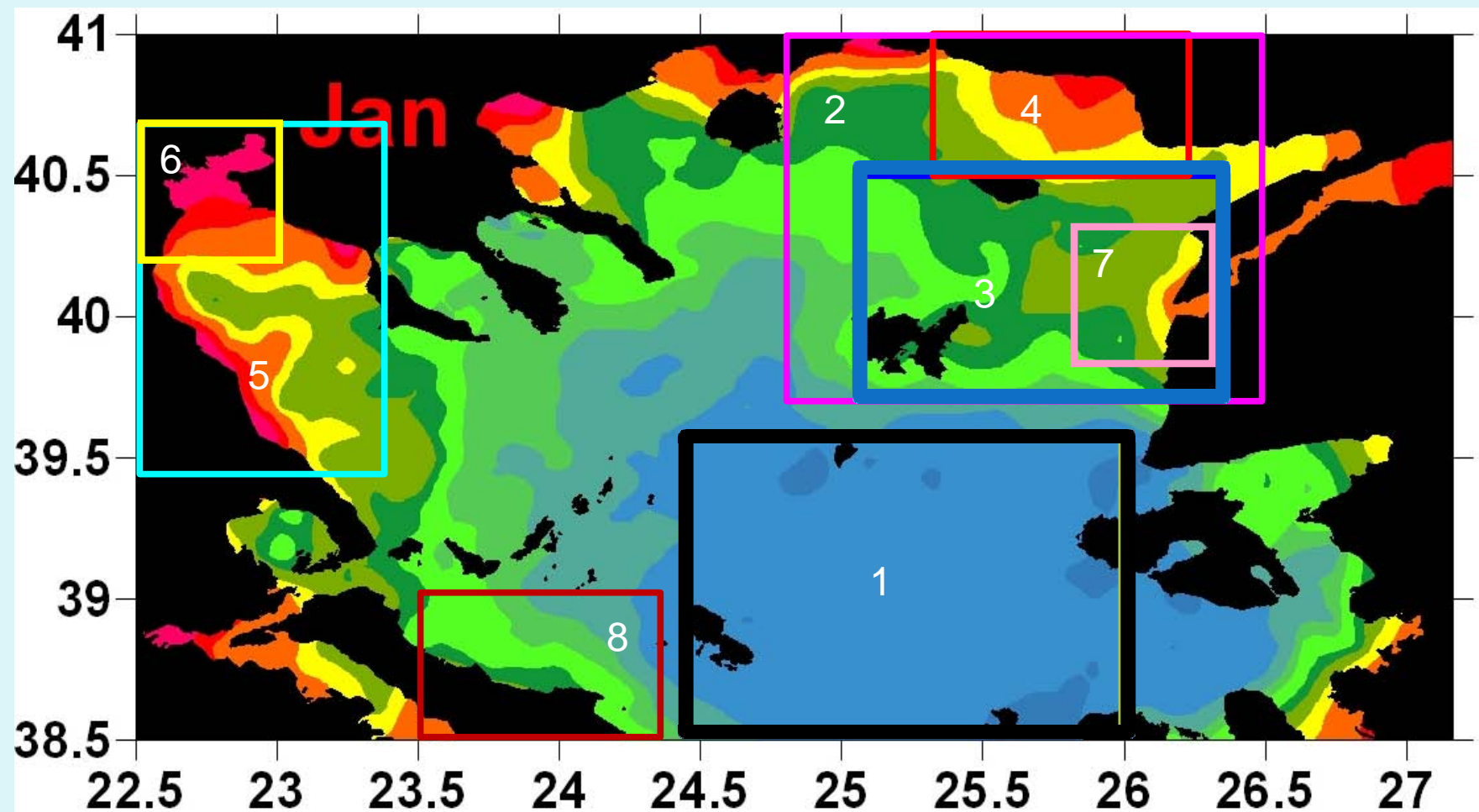
salinity zonal sec. 40.24n Jun 29, 2003 00Z [05.7H]



Feb 09, 2003

June 29, 2003

North Aegean subdomains



Generalised Additive Models (GAMs) for Area 3 (Broad Dardanelles plume area)

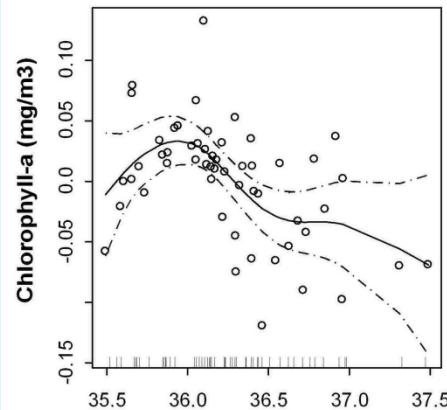
- flexible regression technique
- ability to model nonlinearities using nonparametric smoothers
- advantage over traditional regression methods (General Linear Models)
- suitable for scenario evaluation

🌐 **Salinity:** maximum Chl-a abundance is reached at 35.5-36, whereas after that there is a decline

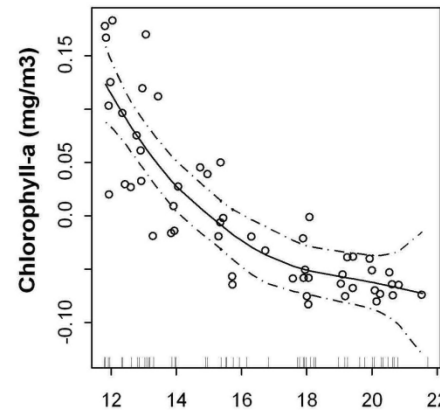
🌐 **SST:** the colder the waters the highest Chl-a (BSW and upwelling)

🌐 **SSH:** high chl-a with high SSH (BSW input)

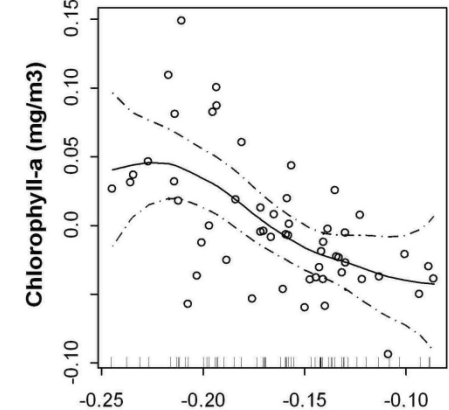
🌐 **Nutrients** Chl-a increases as phosphates increase; while Chl-a decreases after a certain amount of nitrates (0.9) (Phosphate limited environment)



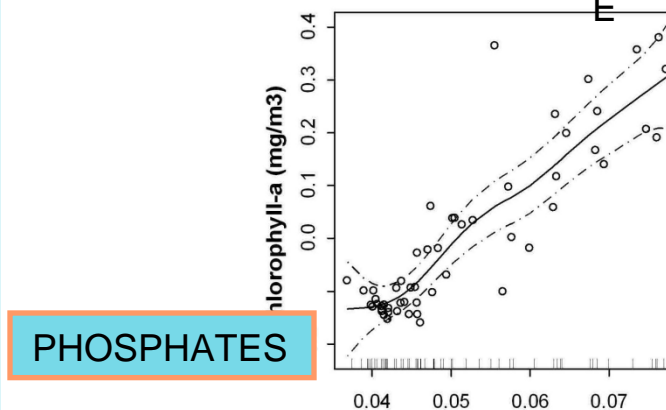
SALINITY



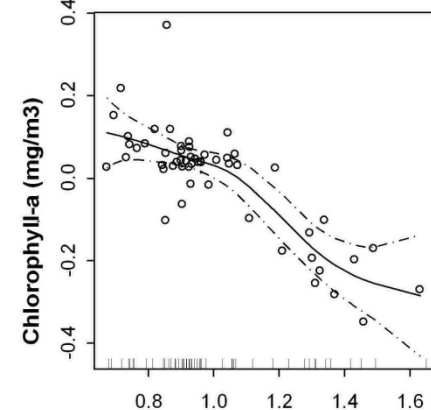
TEMPERATUR



SSH



PHOSPHATES

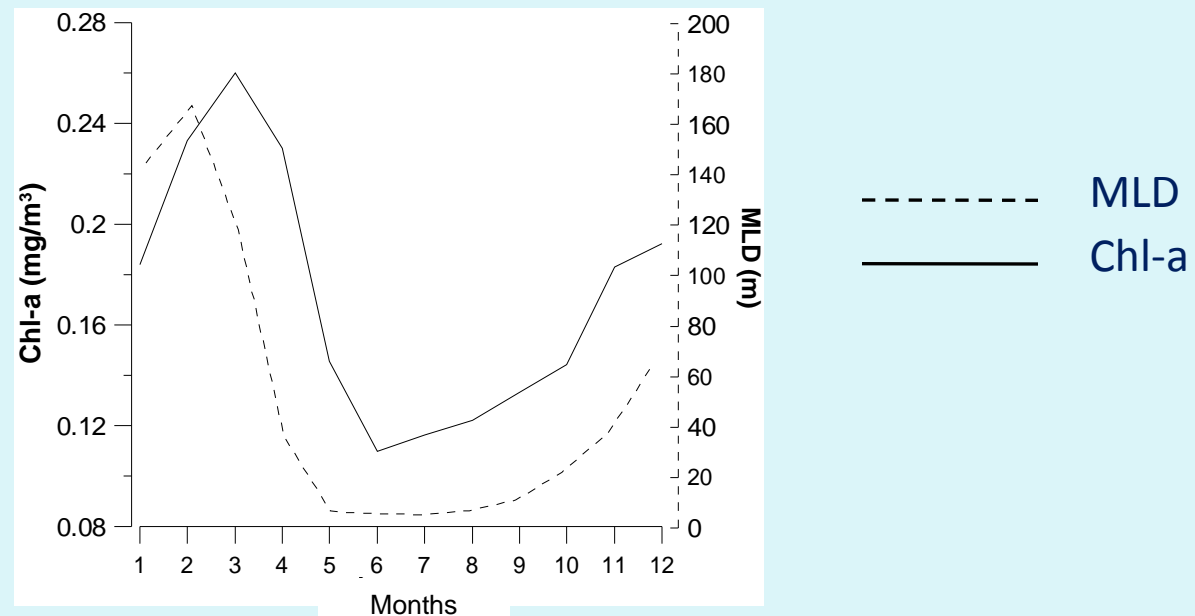


NITRATE

S

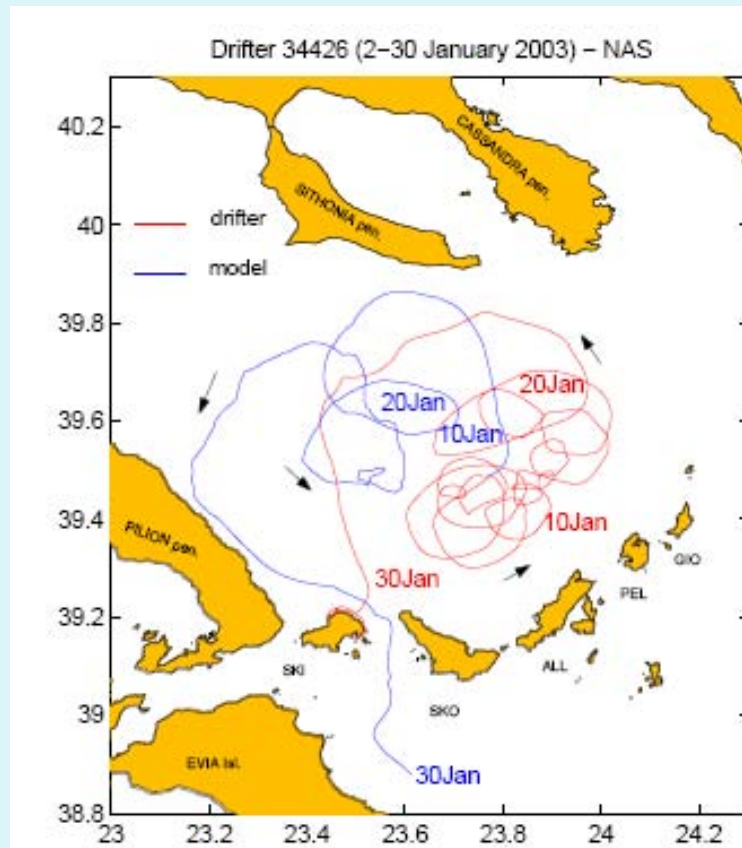
The models stated that the most important factors influencing the Chlorophyll-a in Area 3, are Salinity, SST, SSH, Phosphates and Nitrates (73%) – MLD not important.

Model Mixed Layer Depth vs. observed chl-a in Area 1 (open sea) (2003)



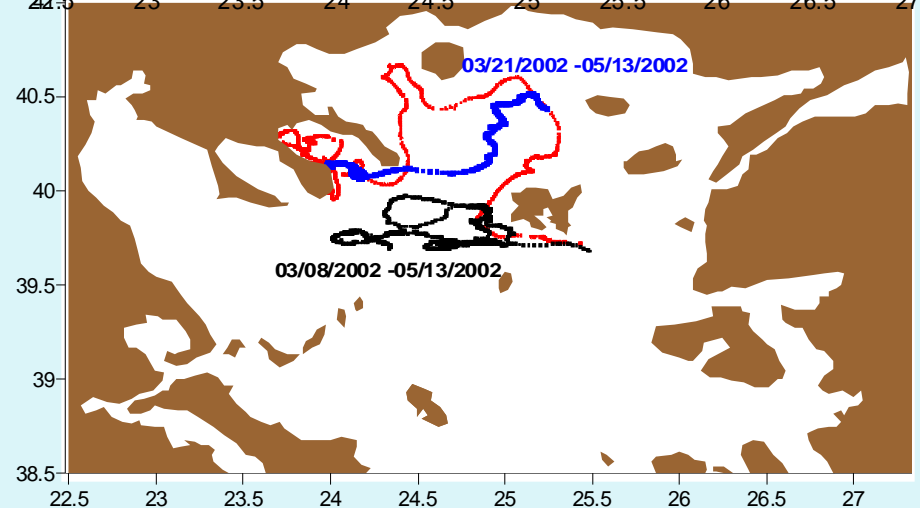
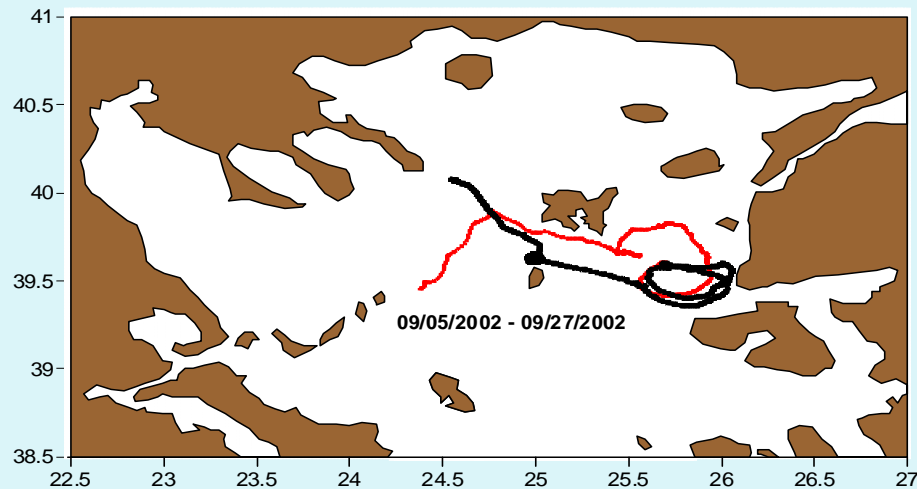
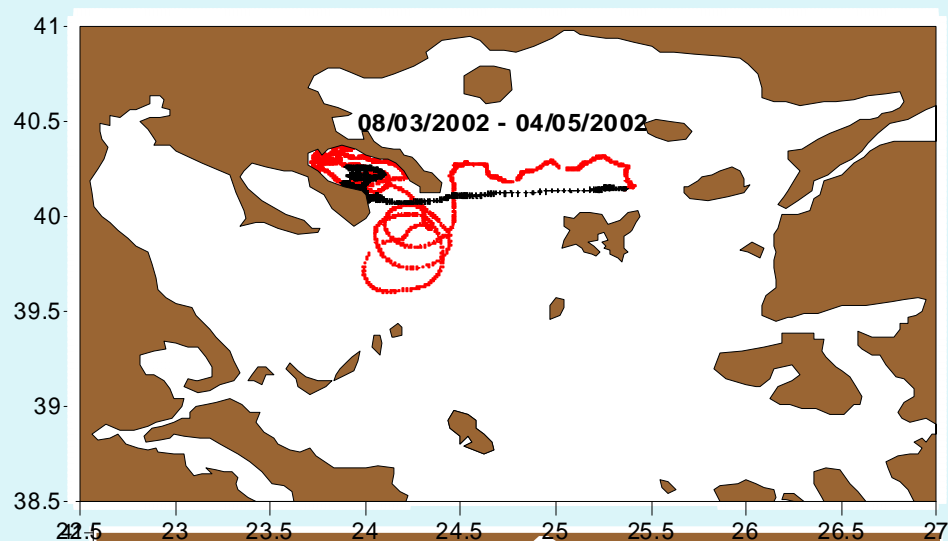
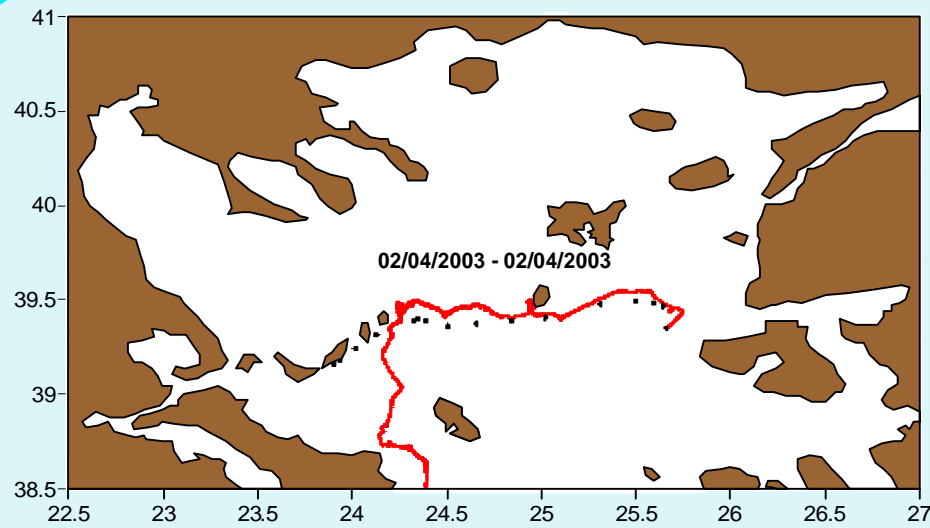
- The NAEG-HYCOM MLD follows the observed Chl-a concentrations in the seasonal cycle
- In summer, the MLD has small values (stratification) preventing the nutrients ascension to the surface layer while in autumn (MLD increase), the nutrient concentration begins to increase resulting in a relative chl-a rise

Comparison of model trajectories to drifter data (2002-2003)



Kourafalou and Tsiaras (2007)

Comparison of model trajectories to drifter data (2002-2003)

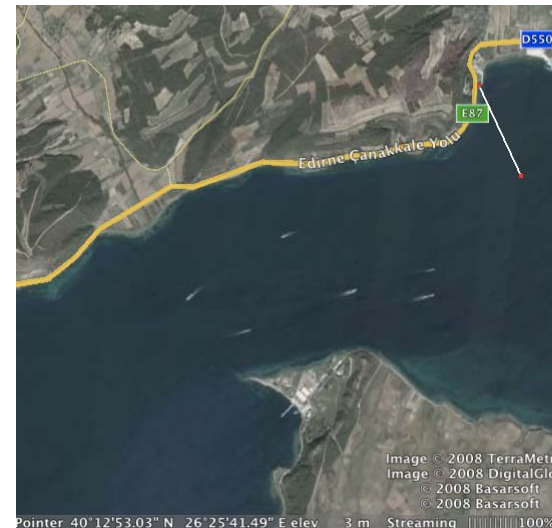
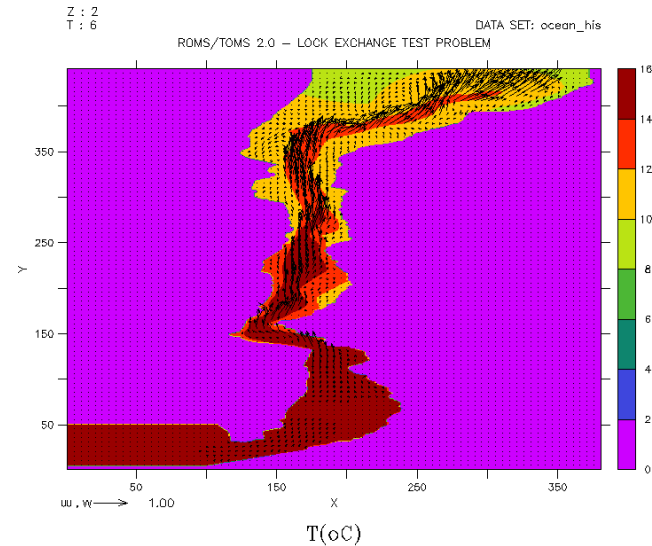
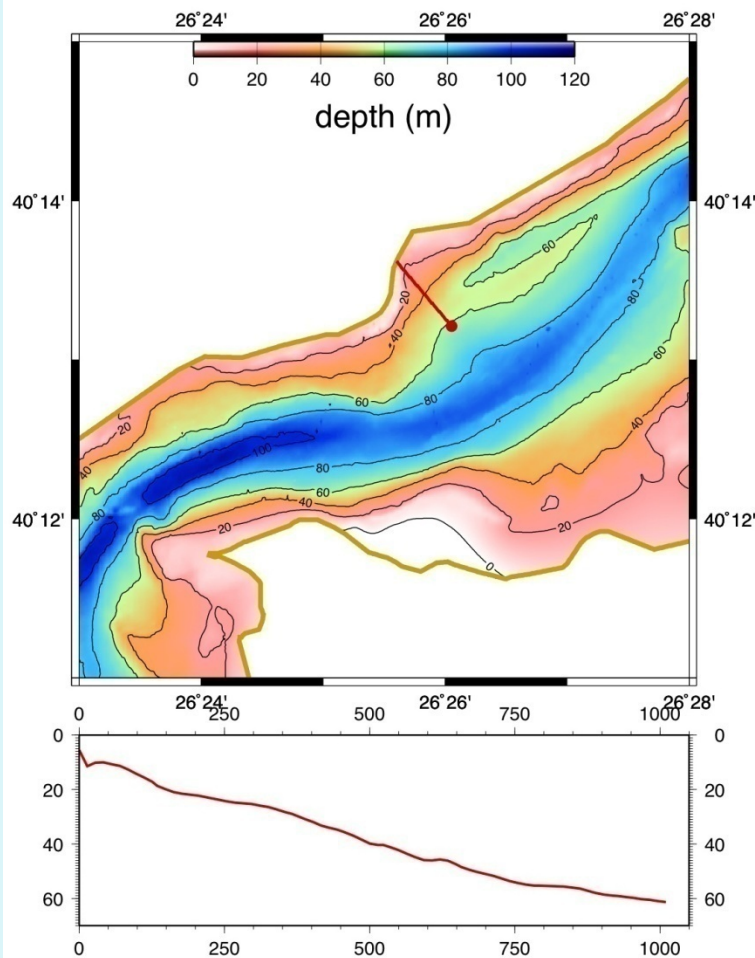


— Drifter data
— Model trajectory
— Model trajectory (delayed)

Measurements and modeling at the Dardanelles Strait

EU-SESAME project

Provided by E. Ozsoy, METU

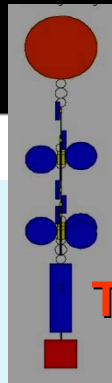
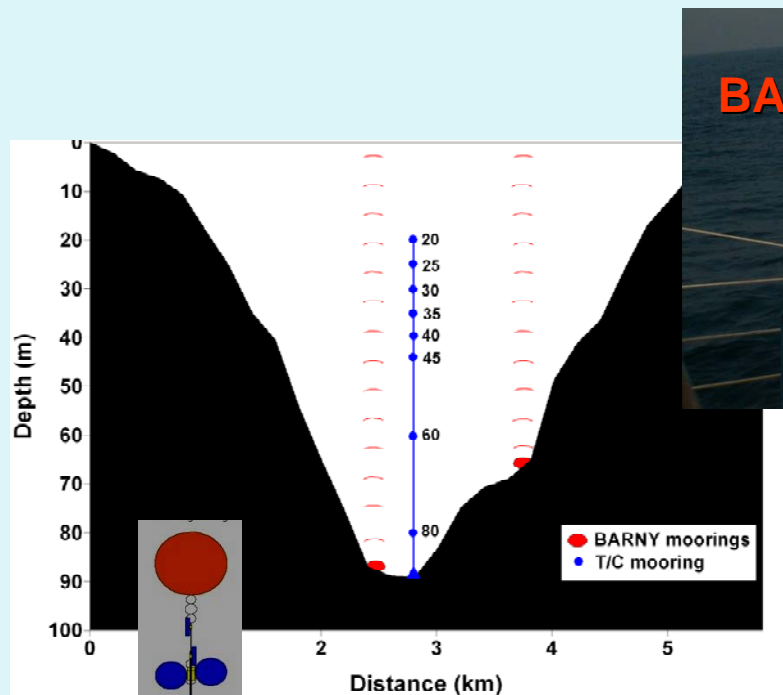


Dardanelles Strait ADCP

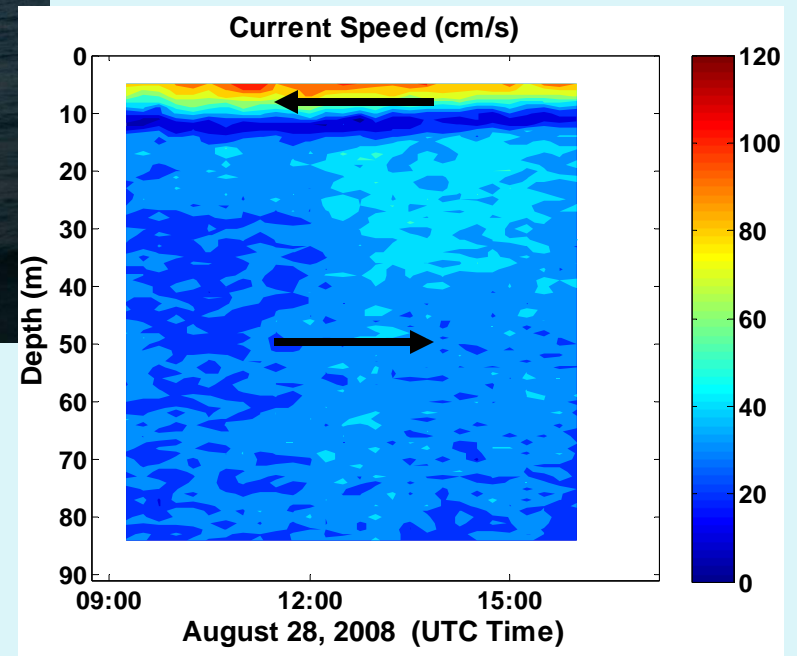


Nutrients, chlorophyll, plankton continuous
measurements station

Ancillary project: NRL-SSC
(E. Jarosz)



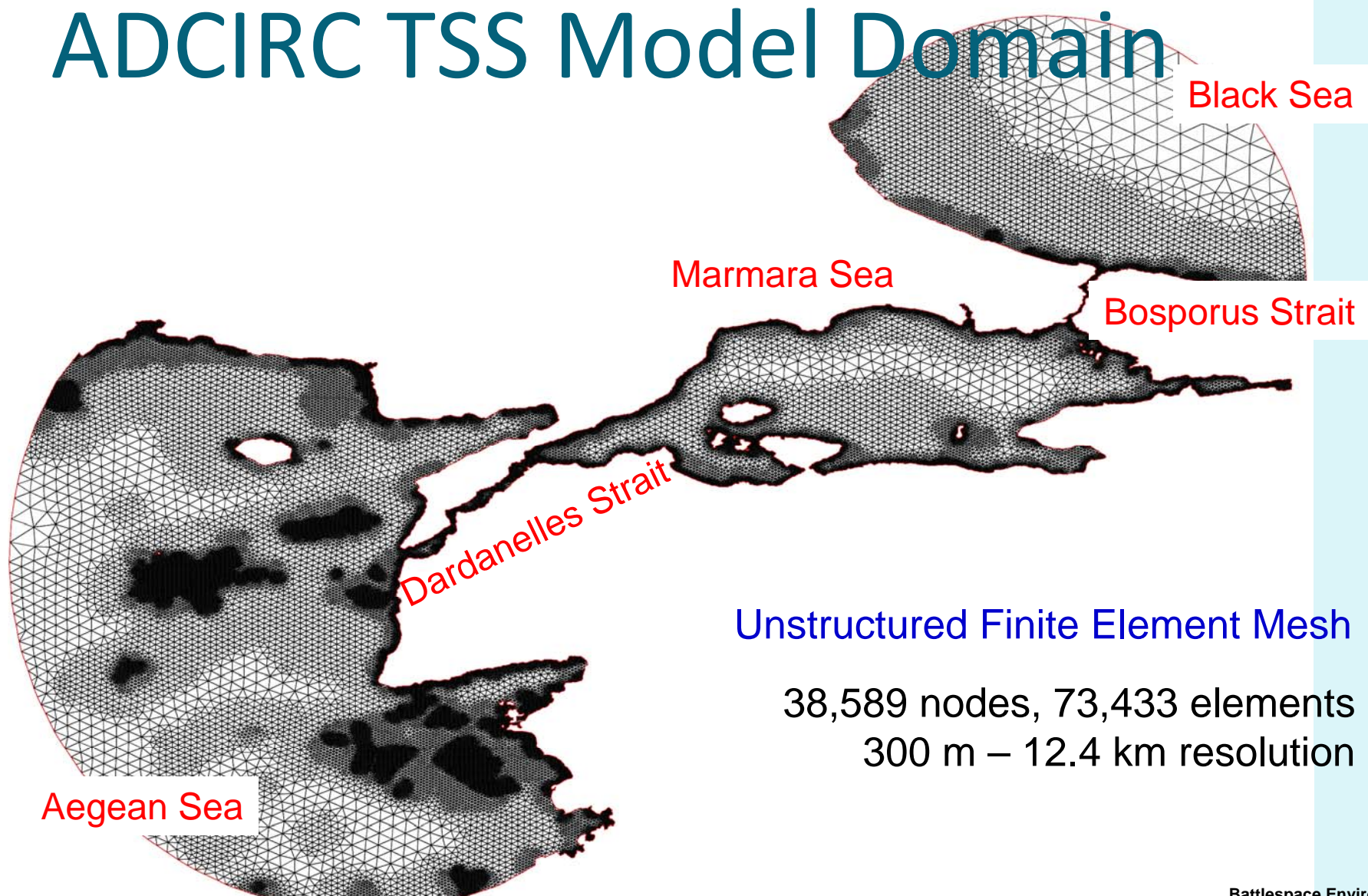
T/C MOORING



***Moorings and Current Observations in the Dardanelles Strait
(Aegean Exit)***

Ancillary project: NRL-SSC
(C.A. Blain)

ADCIRC TSS Model Domain

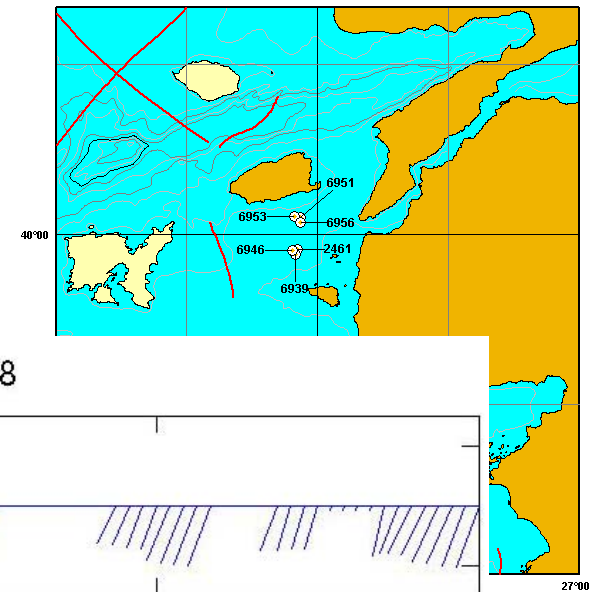
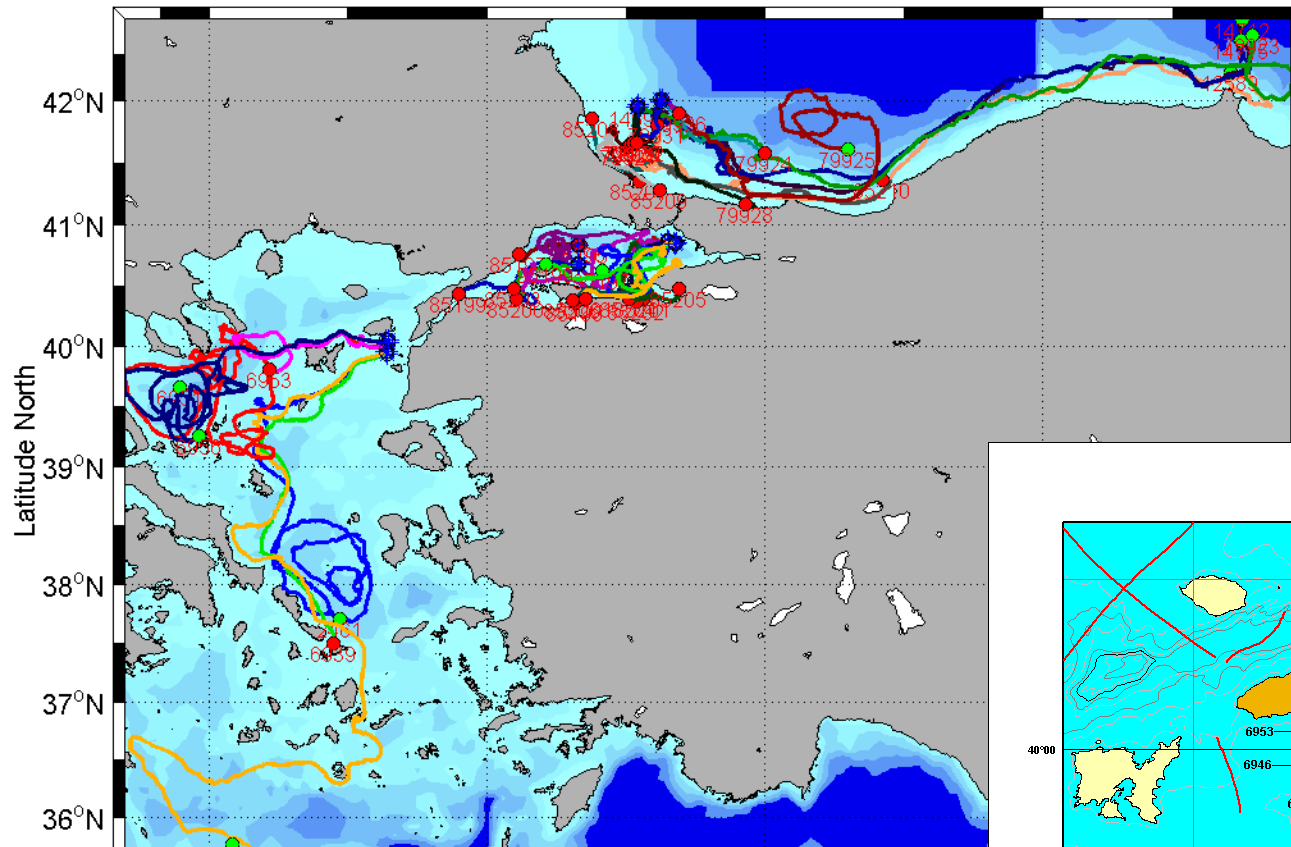


Unstructured Finite Element Mesh

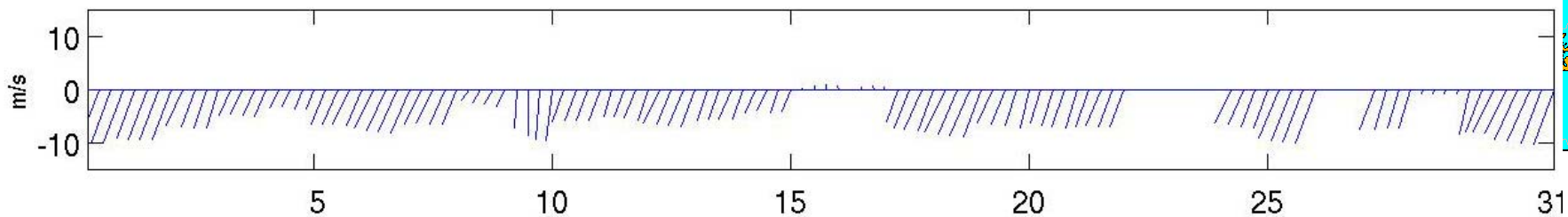
38,589 nodes, 73,433 elements
300 m – 12.4 km resolution

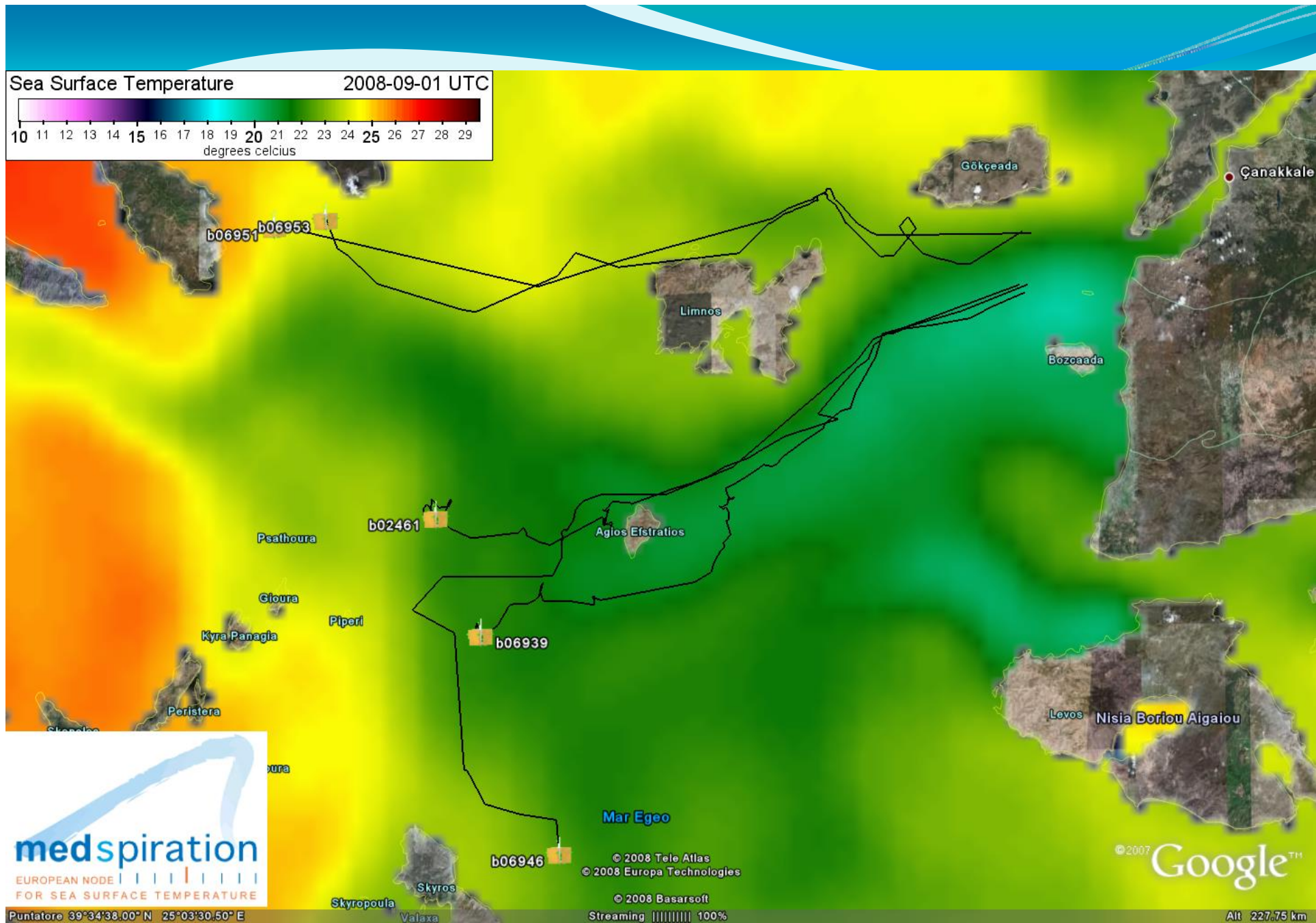
Ancillary projects: OGS and NURC (P.M. Poulain and S. Besiktepe)

NURC DRIFTER INTERP. POSITIONS AS OF 15-Oct-2008



Wind(10m) at point (25.8E,40.0N) - August 2008





Provided by P.M. Poulain, OGS